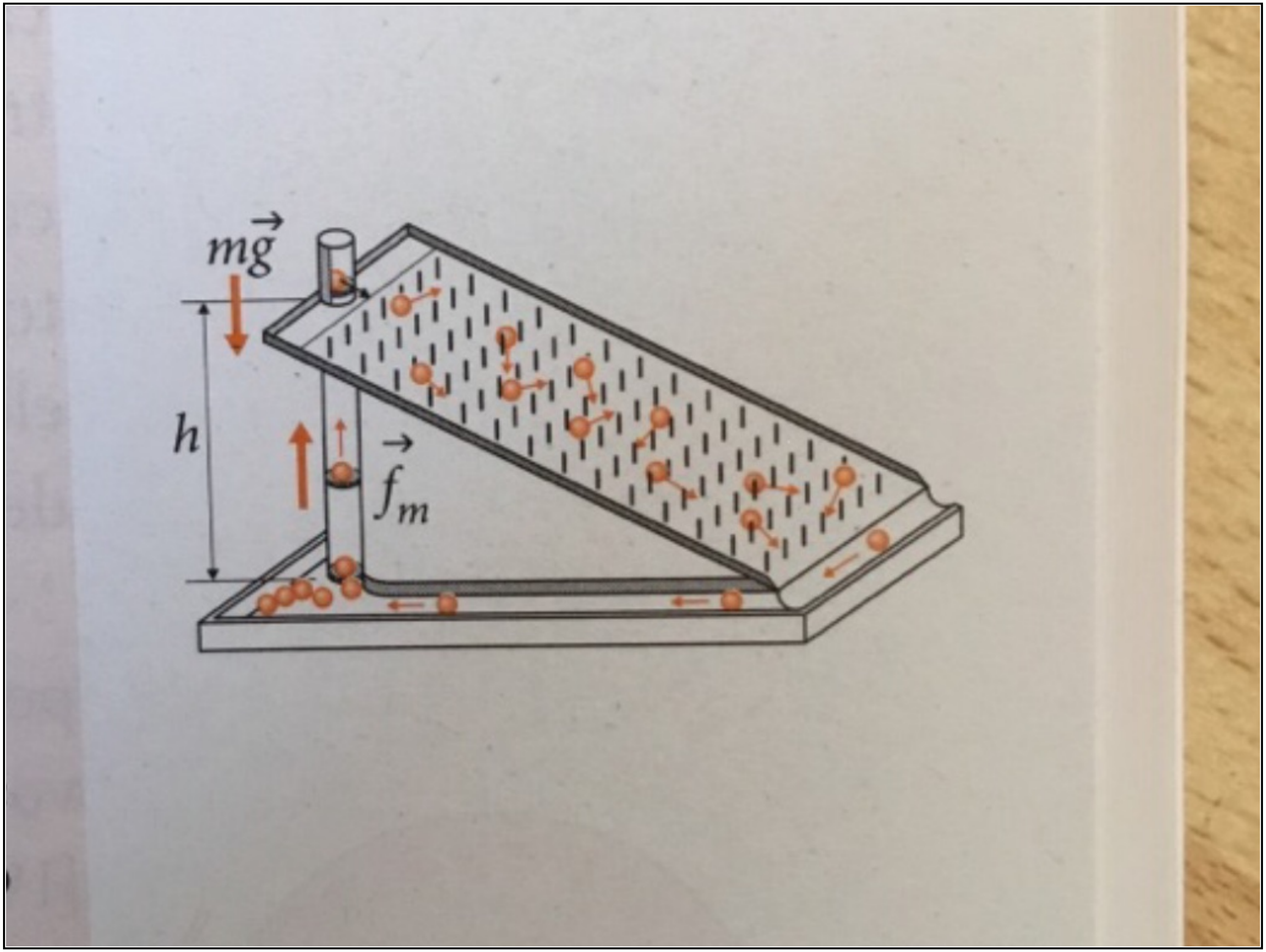
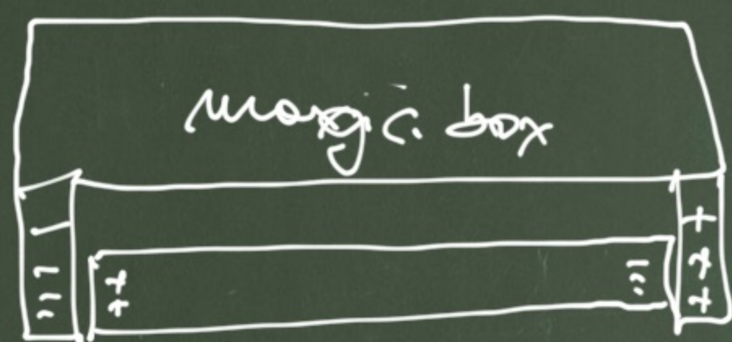

$m\vec{g}$
h
$\vec{f}_m$

ΔV, $\vec{E}$ → $\bar{F}_c = q\vec{E}$ $m\bar{a} = \bar{F}_c = q\bar{E}$

$I = \frac{dq}{dt}$ stazionaria ?

v aumenta sempre ?

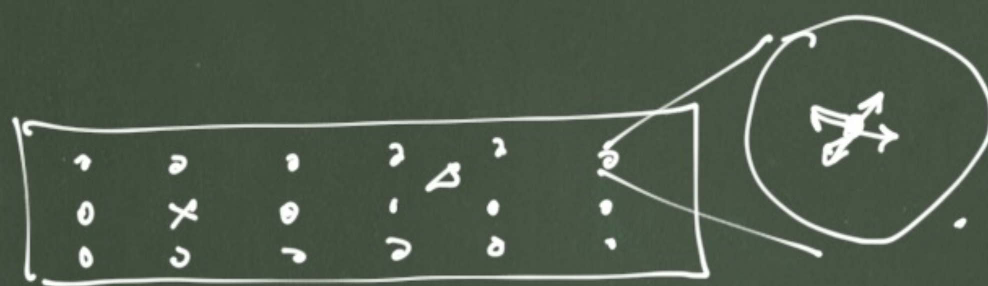


$\frac{1\,C}{1\,s} = 1\,A$

V portatori = finita, costante ?

1) materiali sono imperfetti

2) " vibrano



Drude

$I = GV$ $\quad G = \text{conductance}$

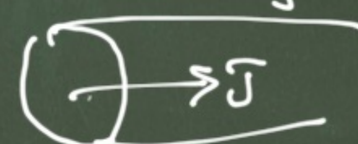
$= \dfrac{V}{R}$ $\quad R = \dfrac{1}{G} = \text{resistance}$

$v_d = \text{drift velocity}$ $\quad \vec{v}_d^{\,+} = v_d^+ \hat{v}$, $\quad \vec{v}_d^{\,-} = -v_d^- \hat{v}$

$$\vec{j} = n^+ e \vec{v}_d^{\,+} - n^- e \vec{v}_d^{\,-}$$

$$= e\left(n^+ v_d^+ + n^- v_d^-\right)\hat{v}$$

$$I = \int_S \vec{j} \cdot d\vec{A}$$



$$v_i \to v_{i+1} = v_i + \frac{eE\tau}{m}$$

τ

tempo di vita media

$$\frac{\sum_i v_{i+1}}{N} = \frac{\sum_i v_i}{N} - \frac{1}{N} N \frac{eE\tau}{m} = v_d$$

(elettroni)

$$v_d = -\frac{eE\tau}{m}$$

$$\vec{J} = -en\bar{v}_d = -ne\left(-\frac{e\vec{E}\tau}{m}\right) \quad \text{(elettroni)}$$

$$= \frac{ne^2\tau}{m}\vec{E} = \sigma \vec{E}$$

$$\sigma = \frac{ne^2\tau}{m^*}$$ conducibilità

$$\rho = \frac{1}{\sigma}$$ resistività

m^* → massa efficace

$$\vec{j} = \sigma \vec{E} \qquad \sigma = \frac{1}{\rho}$$

$$\vec{E} = \rho \vec{j}$$

tensor

$$\begin{pmatrix} \sigma & & \\ & & \\ & & \end{pmatrix} \begin{pmatrix} E_x \\ E_y \\ E_z \end{pmatrix} = \begin{pmatrix} j_x \\ j_y \\ j_z \end{pmatrix}$$

$$P = \bar{F} \cdot \bar{v} = e \bar{E} \cdot \bar{v}_d$$

$$p = nP = e n \bar{v}_d \cdot \bar{E} = \vec{j} \cdot \vec{E} = \sigma E^2 = \rho j^2$$

$\rightarrow$ densità di potenza

$[\rho] = \Omega \cdot m$

$[R] = \Omega$

$\downarrow \quad \frac{V}{A}$

$$I = jA = \frac{AE}{\rho} \qquad E = \frac{\rho}{A} I$$

$$V_1 - V_2 = \int_1^2 \vec{E} \cdot d\vec{l} = El = \frac{\rho l}{A} I$$

Ohm $\quad V = \frac{\rho l}{A} I \equiv RI$

$$\boxed{V = RI}$$

$$\boxed{R = \frac{\rho l}{A}}$$

$$G = \frac{A}{\rho l} = \frac{A\sigma}{l} \qquad [G] = [\Omega \cdot m]^{-1} = \text{siemens}$$

$10^{-8}\ \Omega \cdot m$ (Cu) metallo

$10^{17}\ \Omega \cdot m$ (vetro) isolante

$$dP = p\, dV = p A\, dx = \rho j^2 A\, dx$$

$$P = \frac{\rho I^2}{A} \int_0^l dx = \frac{\rho l}{A} I^2 = R I^2$$

$$\boxed{\begin{aligned} P &= R I^2 \\ &= V I \end{aligned}}$$

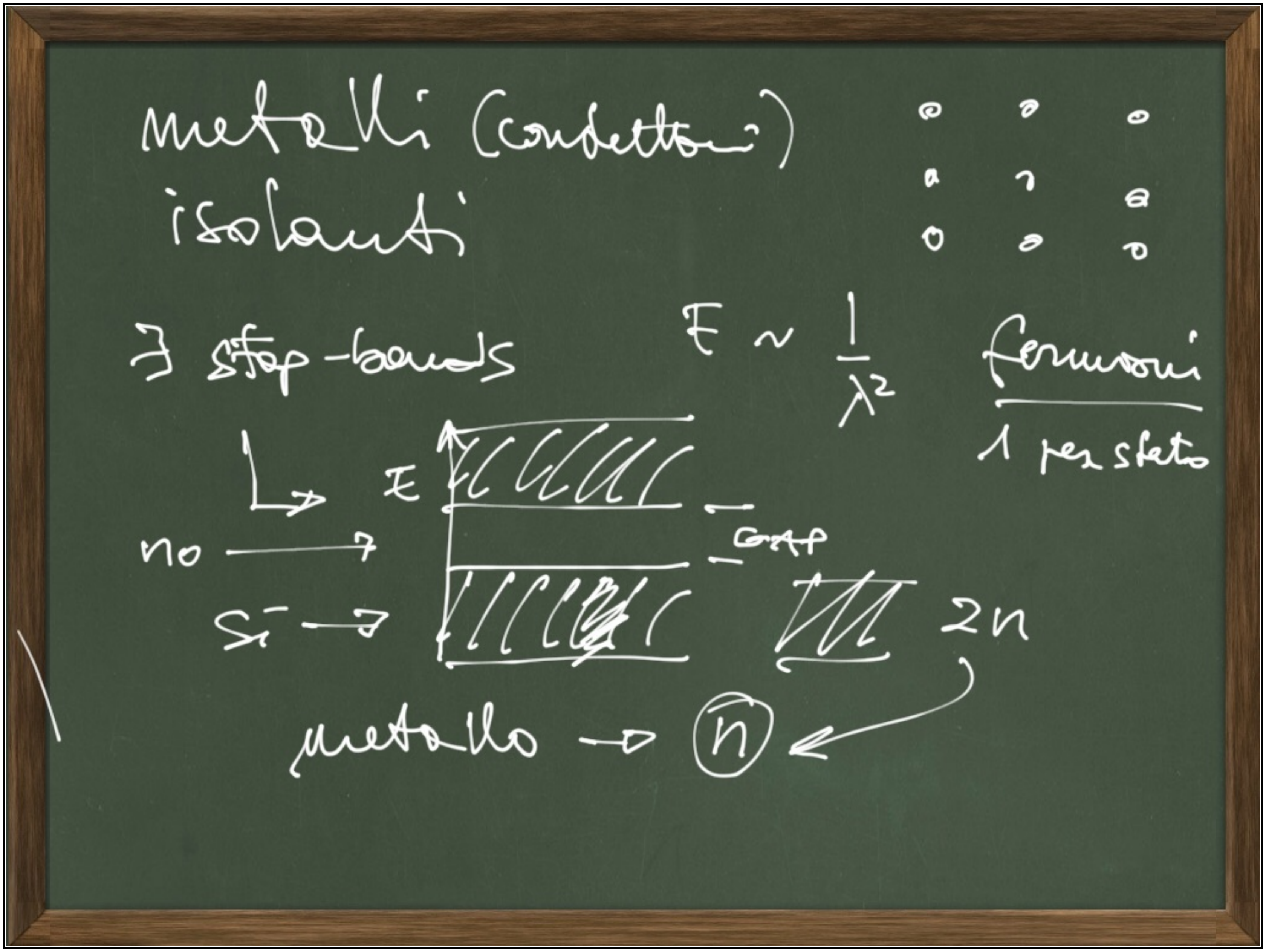
$$V = R I$$

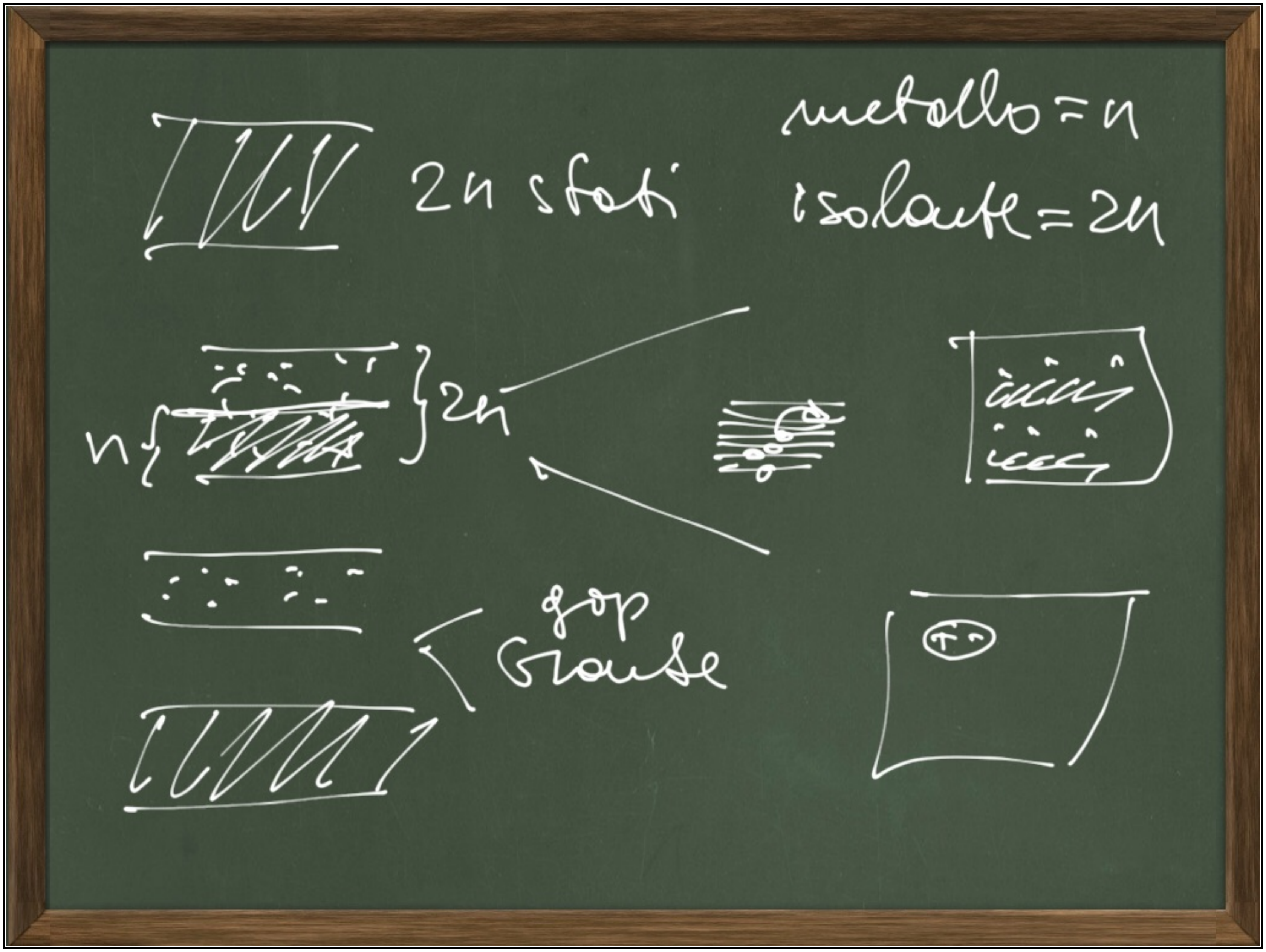
effetto Joule

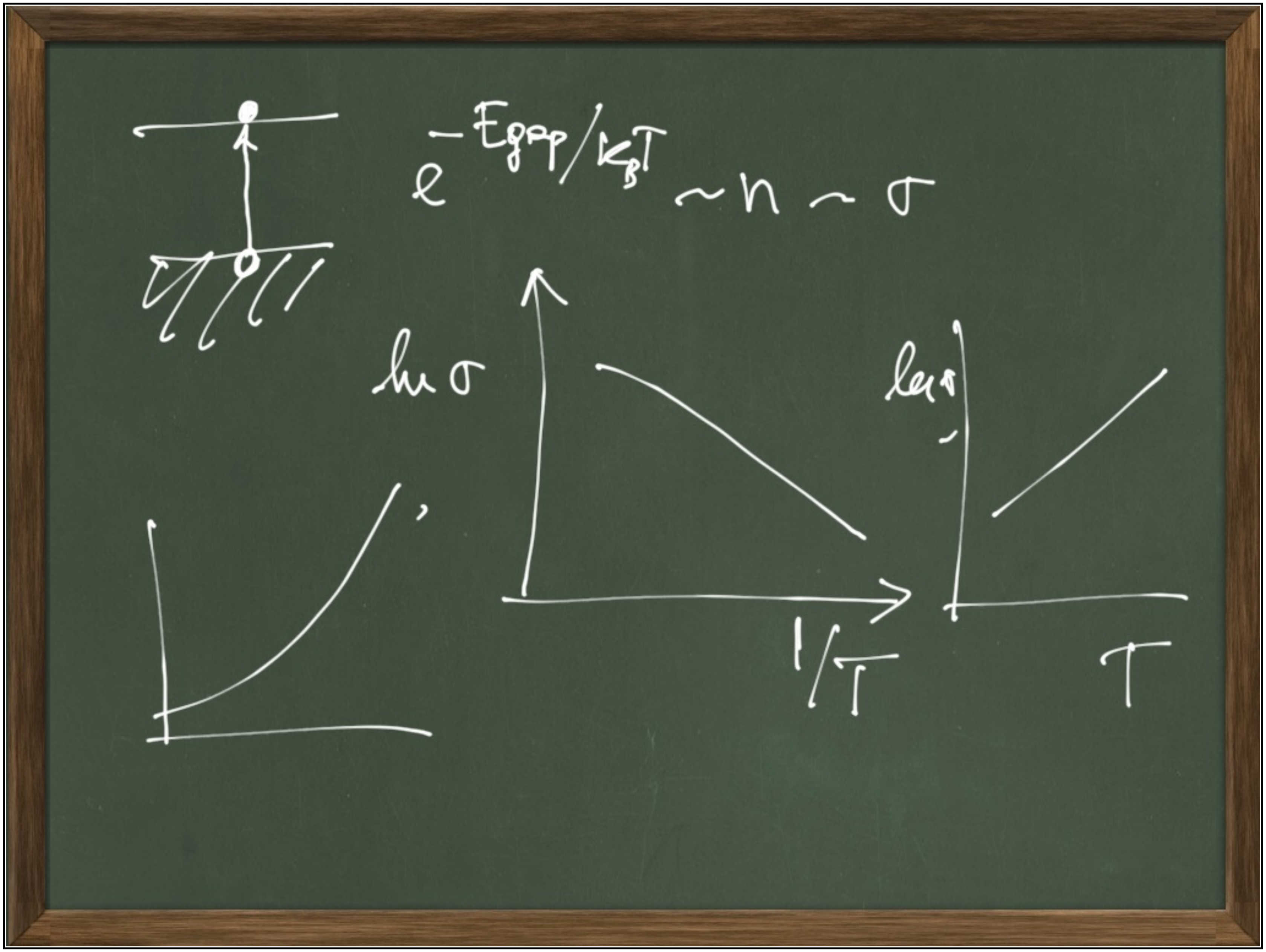
$\sigma \ , \rho \ , p$ Th. sp. da campione

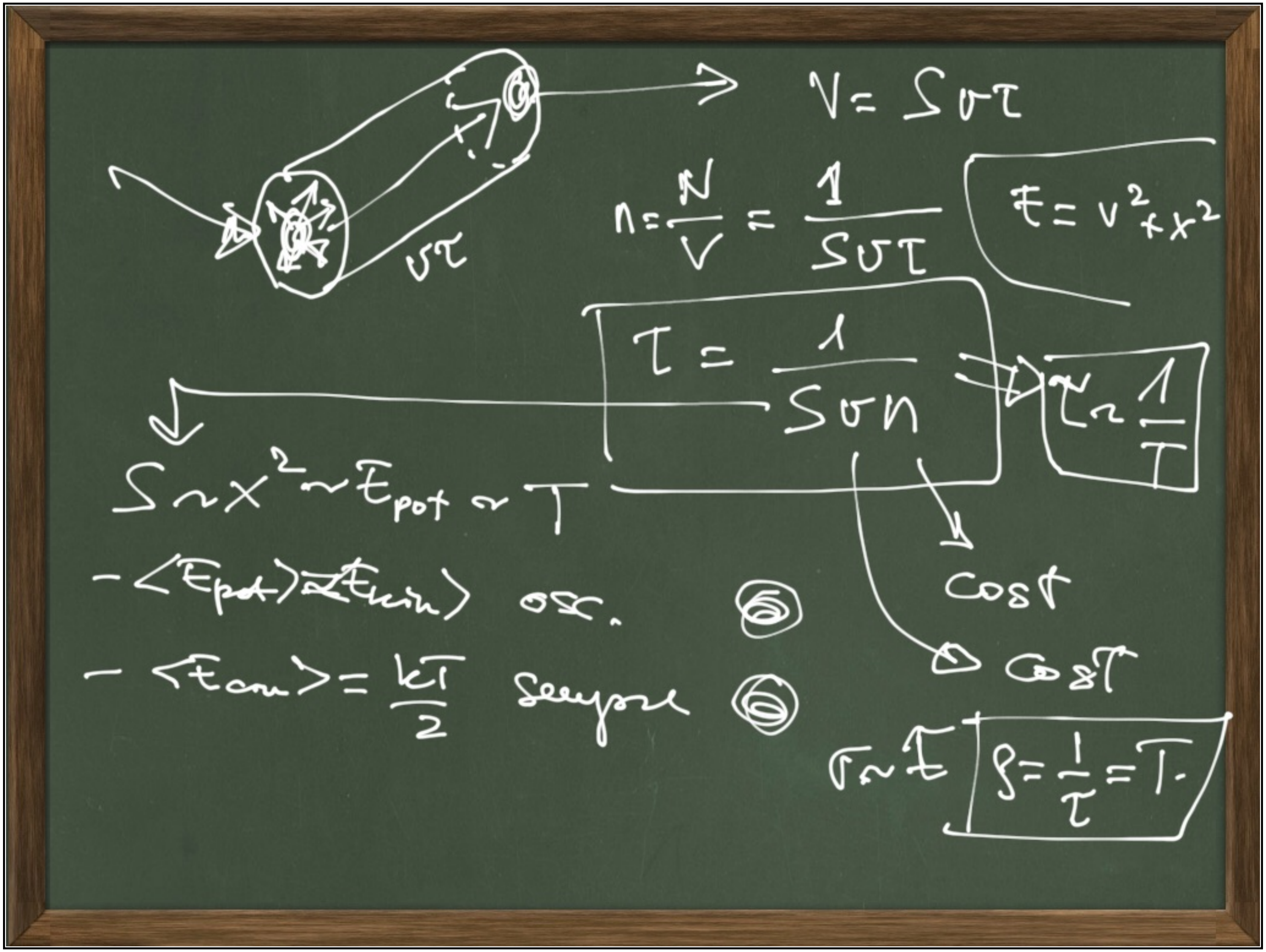
$\rightarrow \quad V = RI \qquad I = GV$

$$P = VI = RI^2$$


metalli (conduttori)
isolanti
∃ stop-bands
E ~ 1/λ²
fermioni
1 per stato
E
no →
GAP
Si →
2n
metallo → n


2n stati
metallo = n
isolante = 2n
n
2n
gap
Grande


$e^{-E_{gap}/k_BT} \sim n \sim \sigma$
ln σ
ln σ
1/T
T


V = SvT
n = N/V = 1/SvT
E = v² + x²
T = 1/Svn
T ~ 1/T
S ~ x² ~ Epot ~ T
cost
cost
ρ = 1/τ = T

O. Sacks

Zio Tungsteno

$$P_{loss} = I V = I^2 R_{loss} = \frac{P^2}{V^2} R_{loss}$$

$$\frac{P_{loss}}{P} = \frac{P}{V^2} R_{loss}$$

$V = 220$ $\quad P = 110\ W$ $\quad I = 0.5\ A$

$(P = VI)$

ogni sec.
110 J

$(V = RI)$ $\quad R = 440\ \Omega$

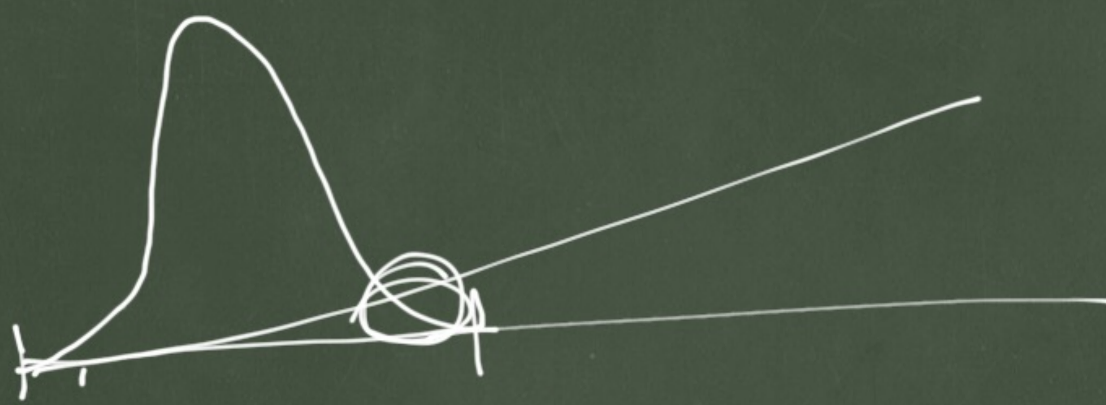
$$c_V = \frac{\Delta Q}{\Delta T} = 25\ J\ K^{-1}\ mol^{-1}$$

$$\Delta T = \frac{\Delta Q}{c_V} = \frac{110\ J}{25\ J\ mol^{-1}\ (M)}\ K = \frac{110}{25\ 1/74}\ K = 325\ K/sec$$

$4\ sec \sim 1500\ K$

Calore va dissipato ⇒ radiazione

corpo nero



2000W $I = 10A$ $R = 22\Omega$